Product Development Team
for
NEXRAD Enhancements

Quarterly Report – 3rd Quarter FY 01

01.6.1 Damaging Winds

Development and enhancement of the Damaging Downburst Detection and Prediction Algorithm (DDPDA) to ensure that it meets the aviation communities' needs for the prediction and detection of damaging winds associated with both wet and dry atmospheric environments, along with larger scale downbursts.

a) Current Efforts

DDPDA efforts have been low-intensity over the past quarter. Six new downburst days have been added to the NSSL damaging wind events database.

Polarization data from Florida continues to be examined.

b) Planned Efforts

Full-time DDPDA efforts will recommence 1 August and continue through the end of the FY.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

01.6.2 Polarization and Frequency Diversity

Continue development of algorithms that utilize polarization data to detect and predict the movement of the volumetric extent of hydrometeors such as hail, rain, snow, sleet, icing conditions, and freezing rain that are hazardous to aircraft.

a) Current Efforts

(NSSL): 1) Hydrometeor Classification Algorithm (HCA) development and deployment.

Work on incorporating a version of the NSSL polarimetric radar Hydrometeor Classification Algorithm (HCA) into a real-time delivery/display system has been completed. In order to facilitate an easy comparison of various radar products, the delivery/display system (the NSSL Warning Decision Support System-II) is designed to ingest and display data from multiple sources. As such, it is an ideal package for delivery of polarimetric radar data and products to operational meteorologists and aviation users.

Initial operational tests began in May of 2001 with the real-time delivery of the HCA (and raw data from the NSSL Cimarron polarimetric radar) to forecasters at the Norman, OK National Weather Service office. For each event, NSSL personnel sat with NWS forecasters to assist them in the interpretation and use of the polarimetric data and products. While several experimental classifications schemes have been tested, the HCA used in the spring 2001 test included seven meteorological, clutter, and biological classes (chosen for their utility in assisting forecasters in the analysis warm-season precipitation events). In the fall of 2001, this classification scheme will be modified to include cold-season precipitation types, such as snow, sleet, and freezing rain.

An example of the algorithm output from the spring 2001 operational test, as displayed by WDSS-II, is included (Fig. 1).

For this case, the HCA clearly depicts a large hail region surrounded by both heavy and moderate rainfall. A large region of rainfall wherein the drop size distribution is dominated by a deficit of small drops was also indicated by the HCA. These “big drop” regions, which can be attributed to drops that originate as melting hail aloft (and fall to ground while still containing ice cores) or the result of coalescence growth in the convective updraft (and fall to ground before significant drop breakup occurs) are characteristic of regions where radar-based rain rate is commonly overestimated. All fields showed remarkable temporal consistency from one sweep to the next.

In total, approximately 5 heavy precipitation events were delivered to operational forecasters in the spring 2001 test. To address aviation interests, coordination will be required to establish a similar capabilities for aviation users, whose insight and feedback will be of vital importance to the evaluation and future development of the HCA. Future work on this initiative, in addition to introducing cold-season hydrometeor types, will also include the collection of verification data sets and refinement of existing classification schemes.

2) Polarimetric radar identification of birds

In recent years, NSSL researchers have collected numerous data sets that clearly show the unique polarimetric signatures associated with birds. As a result, as discussed above, a combined bird/insect category has been included in the HCA for the spring of 2001. From a cursory examination of the data, how-

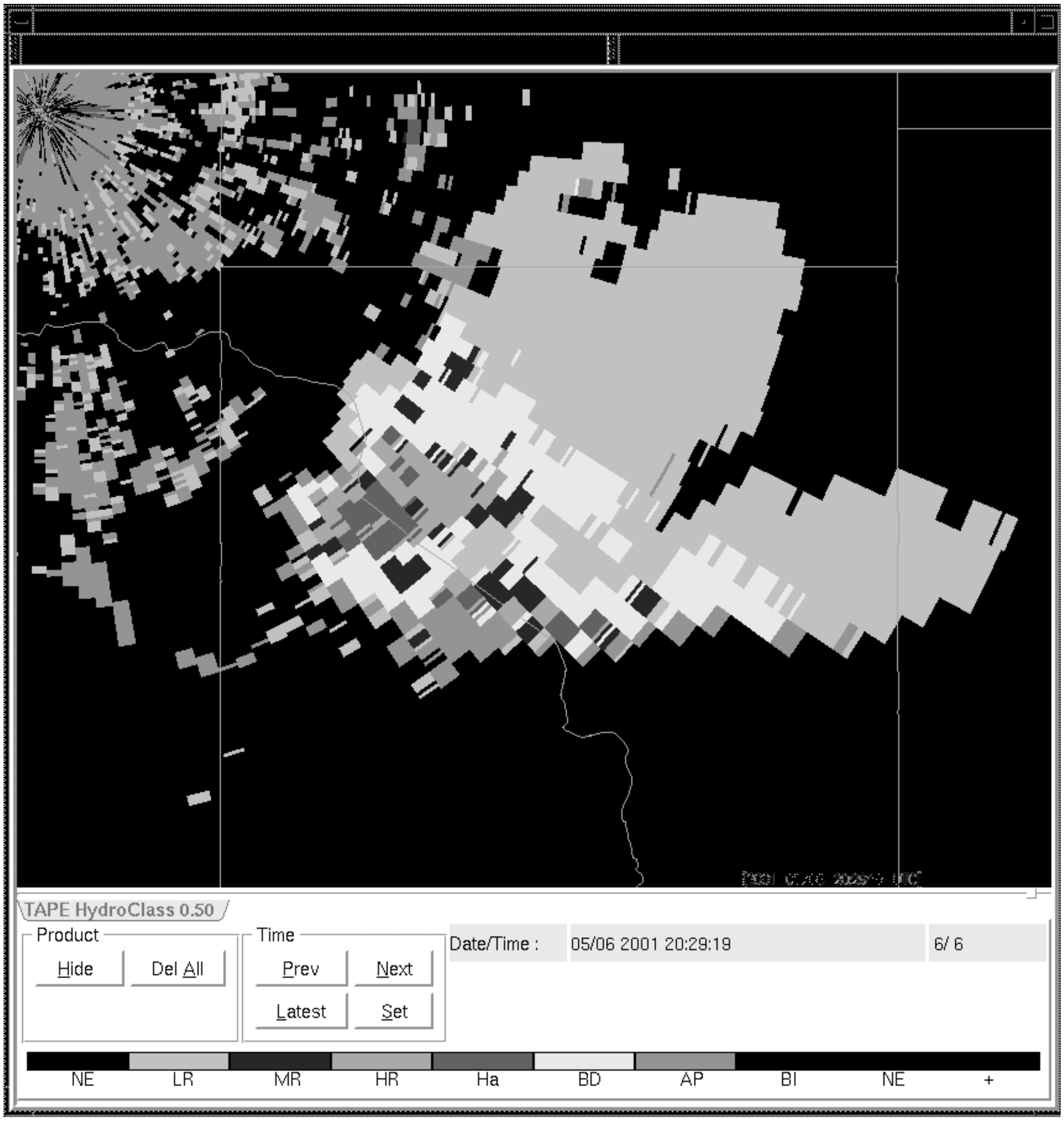


Figure 1. Classification results for a quasi-stationary, severe storm that produced 2 cm hail on May 6, 2001. The warm-season HCA categories shown in this figure are LR=light rain, MR=moderate rain, HR=heavy rain, Ha=hail, BD=big drops, AP=ground clutter and anomalous propagation, and BI=birds/insects.

ever, it is clear that much more information on bird characteristics and migratory patterns can be learned.

Under this initiative, NSSL researchers met with visiting scientists from the Avian Research Laboratory (Panama City, Florida) in May of 2001. Scientists at the Avian Research Laboratory have extensive experience in using neural networking techniques on WSR-88D radar data to evaluate the level of bird strike risk near military air fields. Preliminary discussions were held with the avian researchers on the possibility of collaborations that would examine polarimetric techniques for the identification of bird hazards. Initial steps have been taken to identify cases where both conventional data from the central Oklahoma KTLX WSR-88D radar and polarimetric data from the NSSL Cimarron radar are available for a comparative study.

3) Planning for the Joint Polarization Experiment (JPOLE)

In the past several months, work has progressed on planning for the Joint Polarization Experiment (JPOLE), which will serve as the first operational test of weather radar polarimetry. The updated plans for this operational test, and plans for a complementary science experiment, are discussed in Schuur et al. (2001). Work on Operational and Science Overview Documents is proceeding. Plans call for a multi-seasonal test and evaluation period (to begin in the spring of 2002), and an intensive observational period that will utilize the addition of numerous field facilities for the collection of verification data sets (to begin in the spring of 2003). When completed, the Operational and Science Overview Documents will be posted to the JPOLE web site at http://www.nssl.noaa.gov/~schuur/jpole/ in time for the second JPOLE planning meeting, which is being planned for September of 2001.

Initial discussions have also been held, as part of JPOLE, to develop web-based capabilities for sharing real-time HCA products during future testing periods.

(NCAR):

1) Microphysics studies were begun of the 17 and 22 September 1998 data sets collected in Florida. We are relating hydrometeor distributions as determined with our hydrometeor classification algorithm with storm kinematics. Eventually we hope this work will lead to improved understanding of the distribution of hydrometeors within storms and better parameterizations in numerical cloud models.

2) Refinements are being made to the NCAR polarimetric hail detection algorithm. A previous report (Polarization Algorithm Development: Studies in Hydrometeor Detection; Brandes et al., September 1999) noted algorithm failure (over-warning) in Florida data sets when raindrops were small. Radar and disdrometer data from several hail events are being examined to improve the determination breakpoints of the various parameter membership functions in the NCAR Hydrometeor Classification Algorithm as well as to better define the “rain only” and “mixed phase” boundary in the hail detection algorithm of Aydin et al.

3) Final preparations were made regarding our icing detection paper to be presented at the radar conference in Munich (In-situ Verification of Remote Aircraft

Icing Detection Using S-Band Polarization Radar Measurements). The study indicates that some icing conditions may be detectable with operational radars.

b) Planned Efforts

NSSL: Continue work on and evaluate real-time data display system for the Cimarron polarimetric radar. NCAR: Continue the work on a freezing level algorithm and the verification of particle designations using the Florida data sets.

NSSL/NCAR: Combined: Plan JPOLE coordination meeting for later in the calendar year.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

01.6.3 Circulations

Continue to enhance NSSL's Mesocyclone Detection and Tornado Detection Algorithms (MDA, TDA) while developing in parallel a new algorithm which combines MDA and TDA into one algorithm which detects and analyzes all circulations - the Vortex Detection and Diagnosis Algorithm (VDDA).

a) Current Efforts

Technical Direction changes were submitted and approved. No other progress to report.

b) Planned Efforts

Dr. Caren Marzban will be developing enhance neural net equations for MDA based upon a significantly enhanced data set. These efforts are slated to begin in July. Such an analysis will provide enhanced detection of particularly significant storms for the CIWS experiment.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

01.6.4 Technical Facilitation

Continue to work through the process of algorithm transition to the operational WSR-88D system. This also includes development of a Common Operations Development Environment (CODE) and Application Programmer Interfaces (API's) for a more rapid integration of algorithms into the operational system.

a) Current Efforts

1. Three-dimensional display of previously gridded data. The Mosaic algorithm developed at NSSL takes data from multiple radars in a domain and creates a 3D volume of radar reflectivity data, choosing the best estimate of reflectivity at every point within the 3D grid. Interactive viewing of this 3D volume was implemented in the WDSS-II system (Fig. 2). A full-resolution cross section can be formed out of any 3D volume product at any arbitrary angle or viewing direction (Fig. 3).

2. Data and products from polarimetric radar (Cimarron) are now part of the WDSS-II system. These include radar reflectivity, Hydrometeor classifier output, differential reflectivity, etc. (Figs. 4 and 5).

3. Data from multiple sources (different WSR-88D, polarimetric radar, Mosaic algorithm, etc.) can be displayed simultaneously in a true 4D system along with arbitrary GIS shape files (Figs. 6, 7, 8, 9 and 10)

4. The system was field-tested in real-time with the following products at the Norman Forecast Office:

a. data from several radars including KFWS, KAMA, KTLX,

b. rapid-update versions of the SSAP algorithms,

c. QPESUMS, Mosaic algorithms,

d. Polarimetric radar products, and

e. K-Means clustering algorithm.

b) Planned Efforts

A single-radar, virtual-volume product has been designed and built. The visualization for the virtual volume is currently being developed. Also, display of trends and tracks is being developed (Figs. 11, 12, and 13).

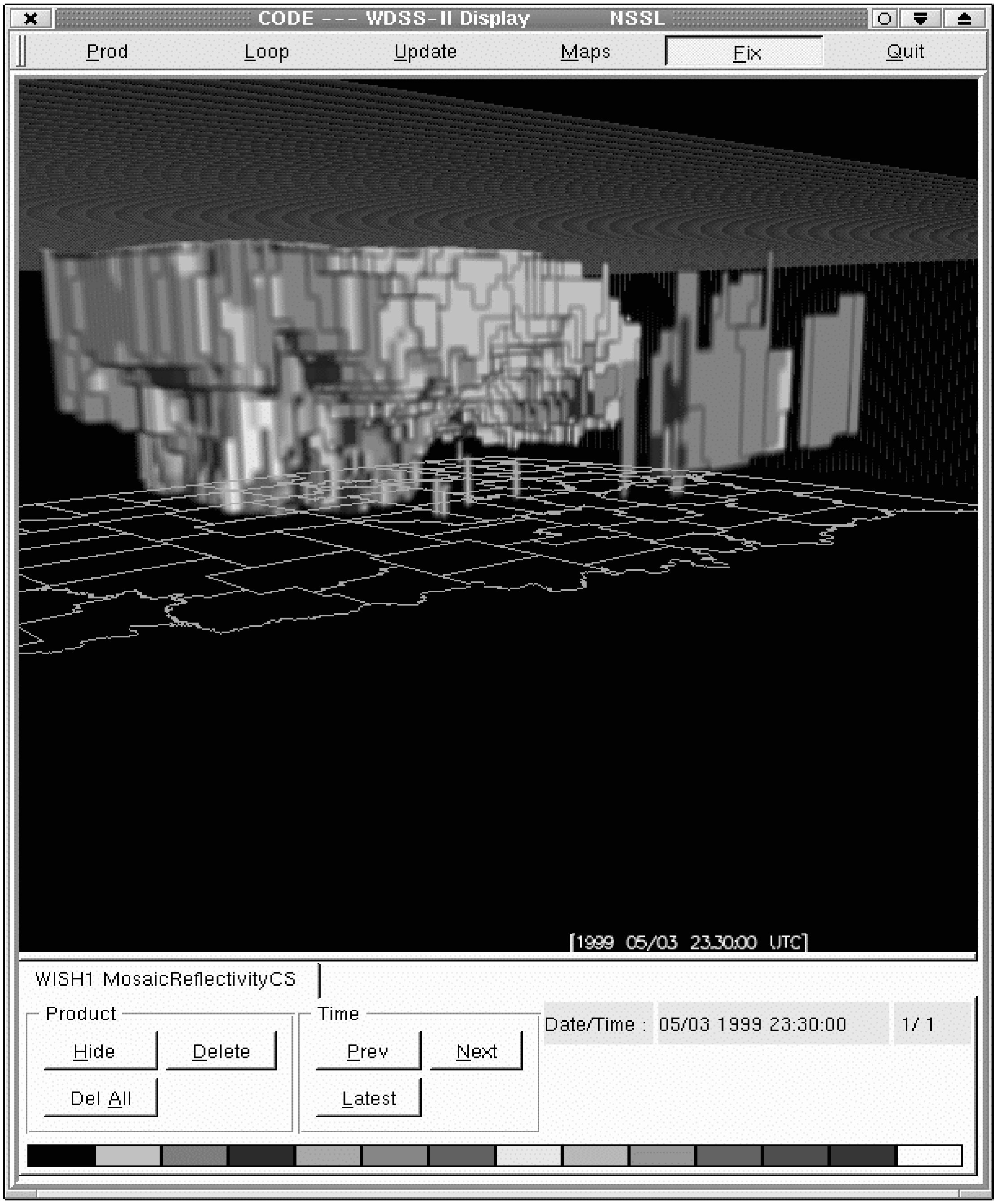


Figure 2. Example of interactive view of a radar data volume.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

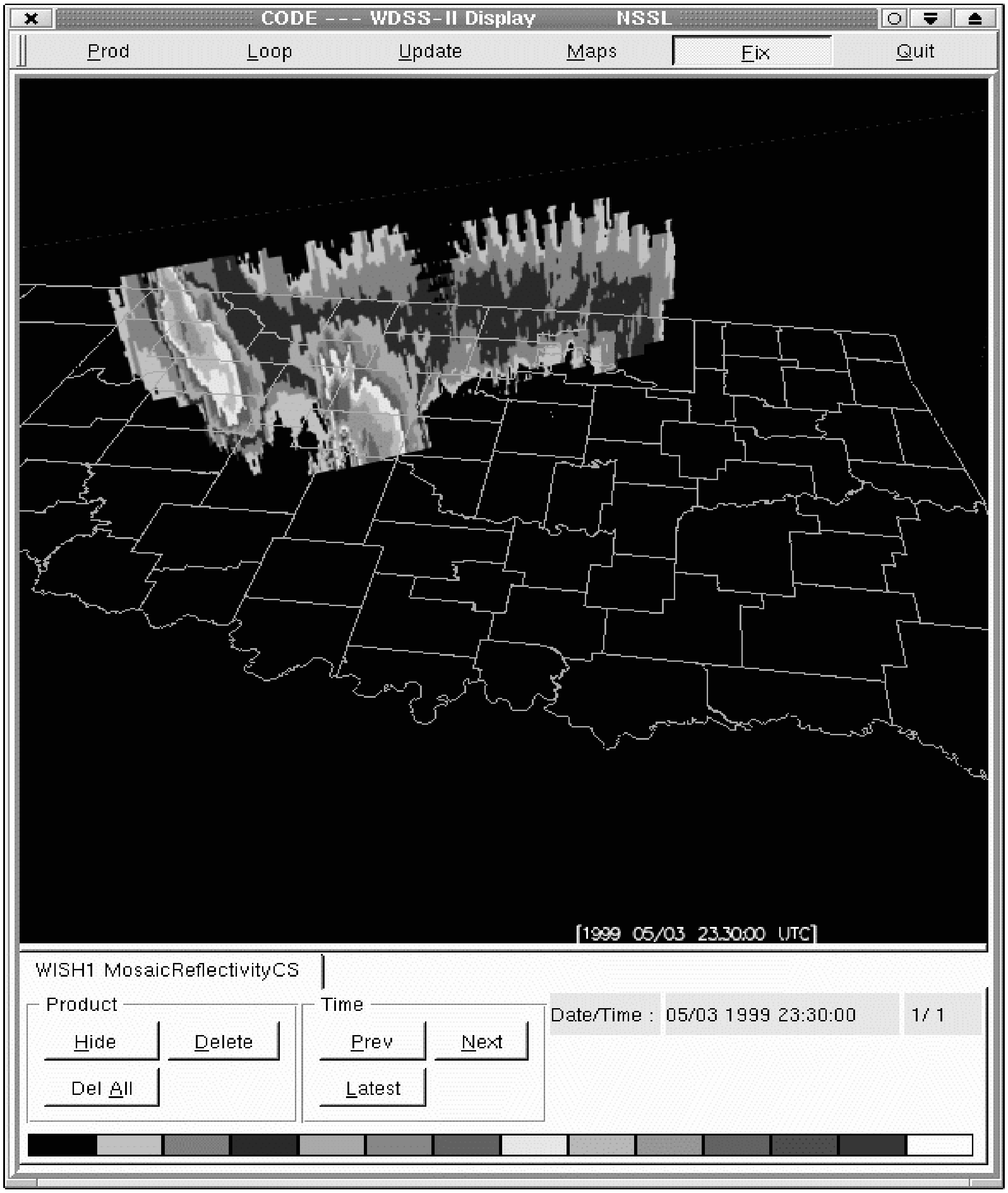


Figure 3. Example of an arbitrary cross section taken through the data shown in Fig. 2.

e) Activity Schedule Changes

None.

01.6.6 Rapid Update

Develop software that produces algorithm output after each tilt, thus providing immediate information to the users.

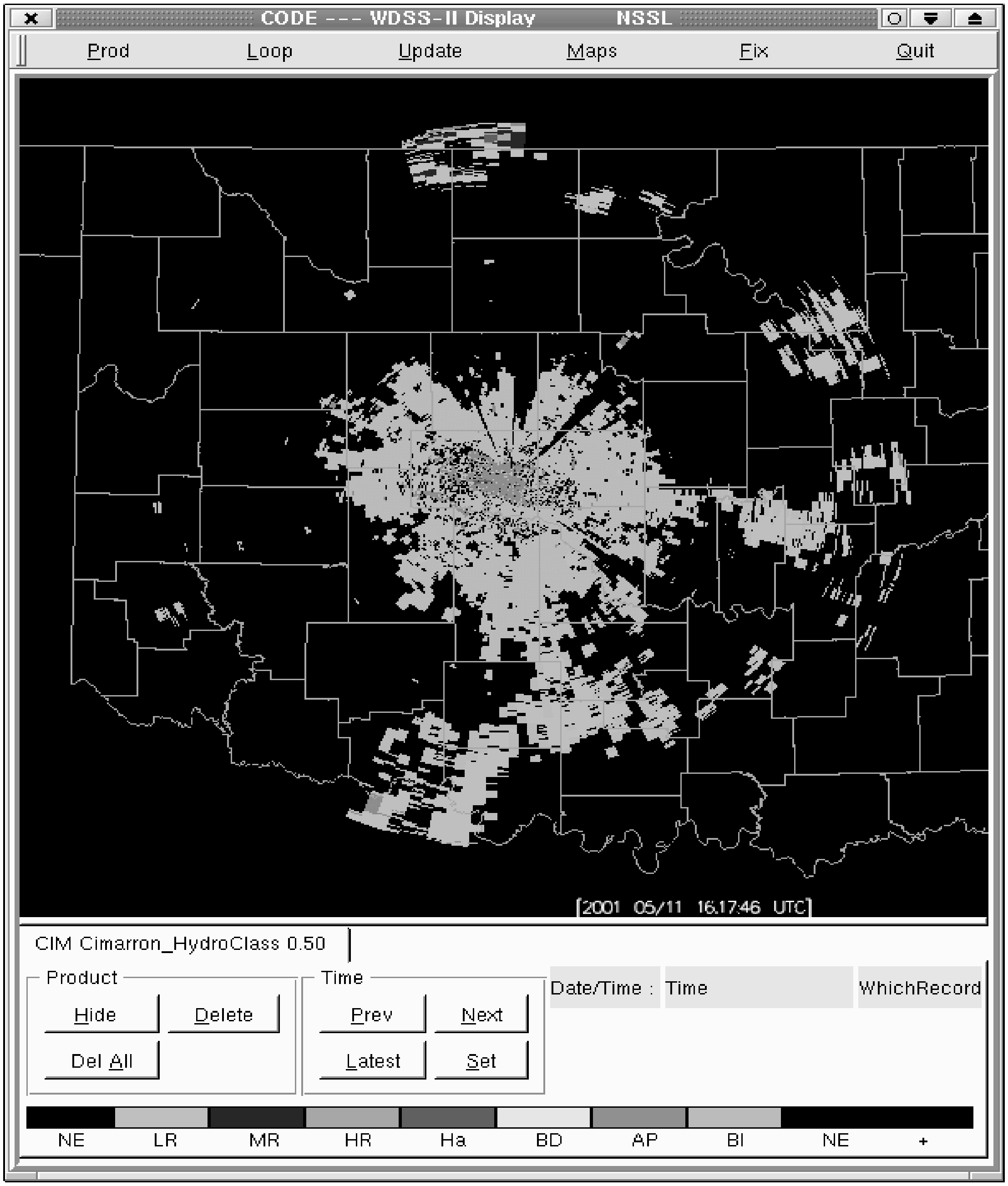


Figure 4. Hydrometeor Classification Algorithm output displayed on WDSS-II.

a) Current Efforts

Real-time testing of Rapid Update output commenced during May at NSSL and the Norman National Weather Service Office. Data are displayed in the WDSS-II system at both locations. Observations of the output have revealed several issues that need to be investigated in more detail or that have been addressed during the testing:

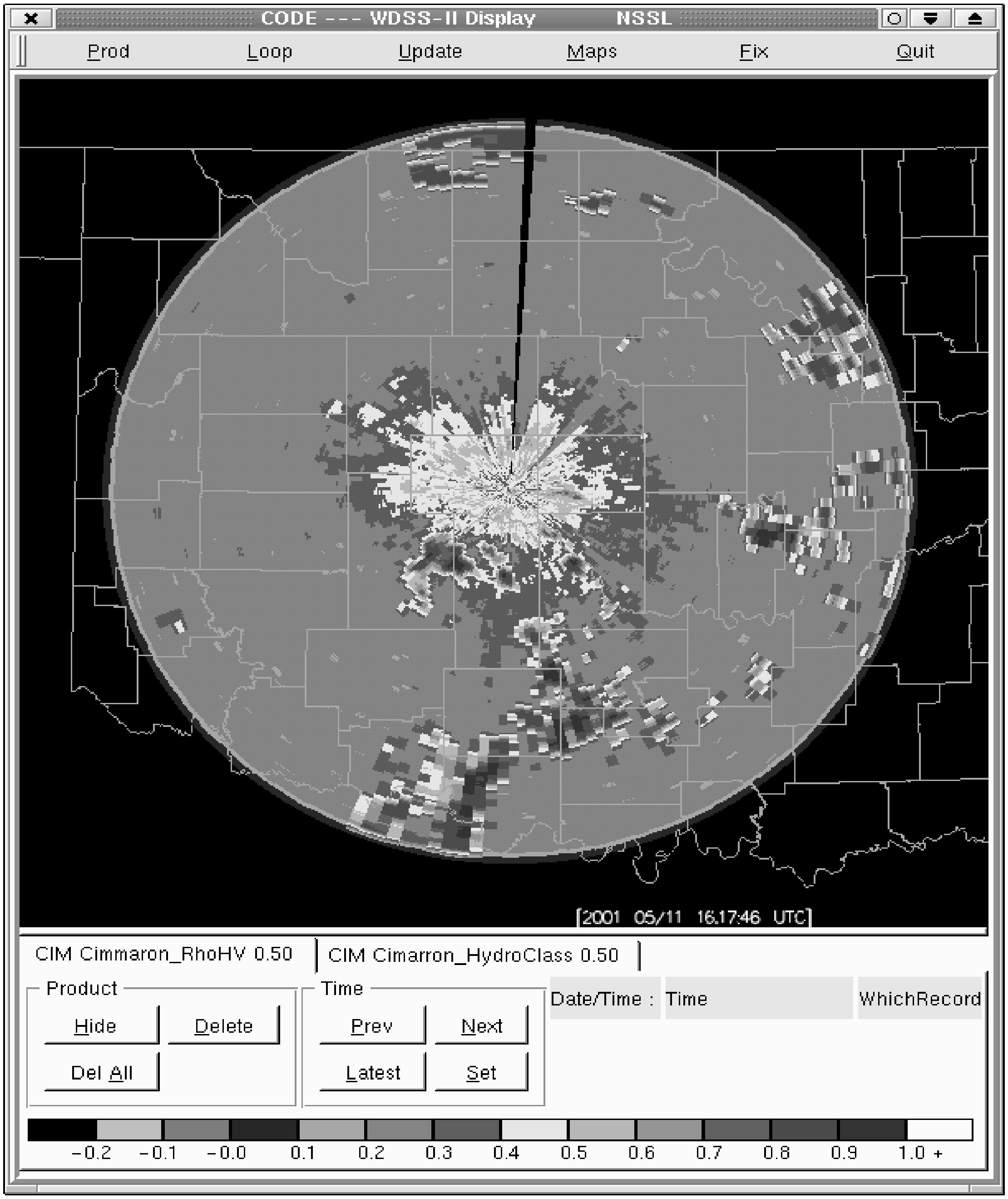


Figure 5. Display of specific differential phase, ρ_{hv}, on WDSS-II.

- A bug that was causing erroneous TDA forecast tracks was fixed.
- MDA neural network output is being corrupted when in Rapid Update mode. The cause of the corruption has not been determined.
- Storms cells that are identified by the SCIT algorithm may disappear for a while each volume scan. The correct behavior should be for cells to remain listed in their old location until the new location has been determined for the new volume scan.

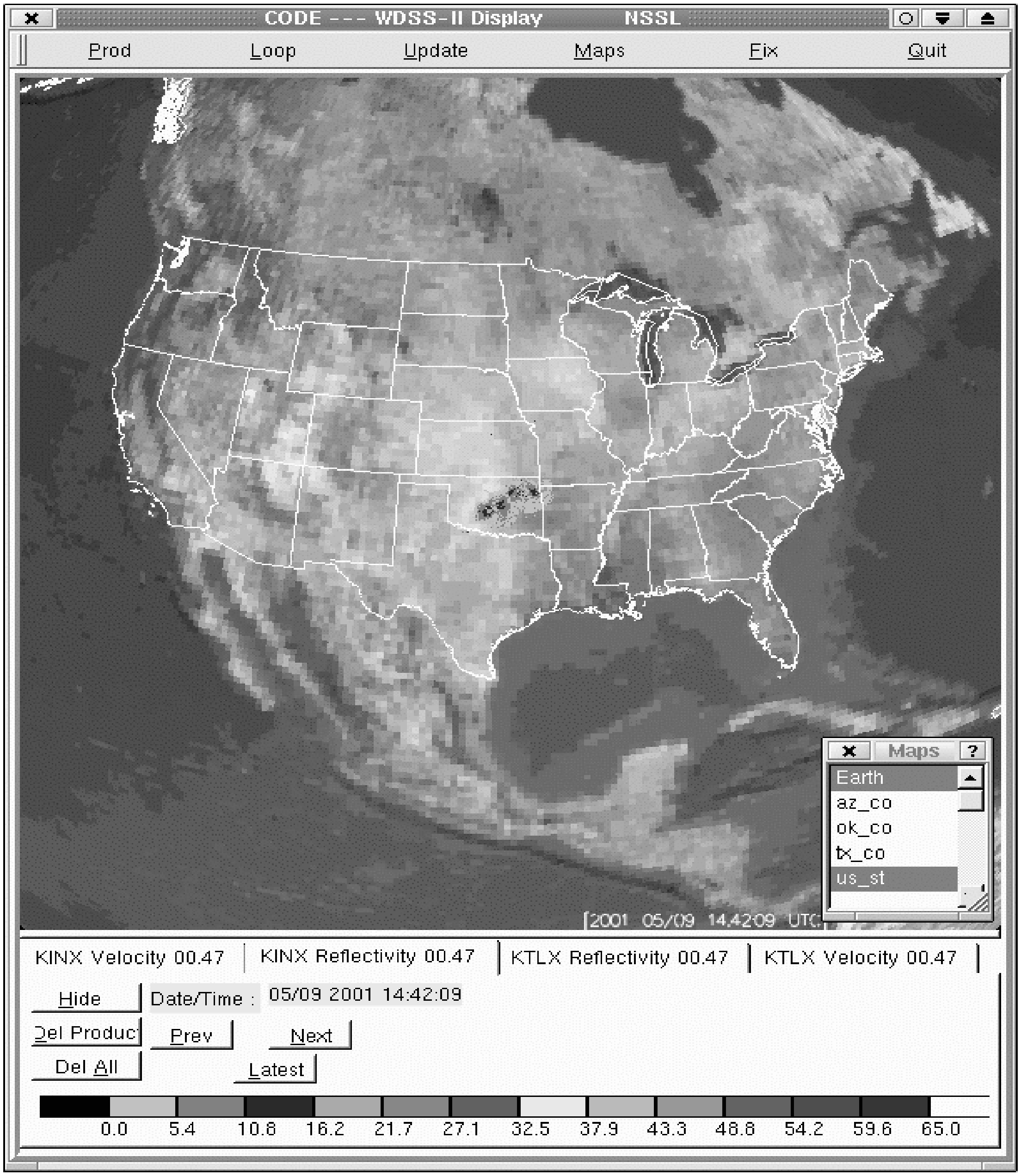


Figure 6. Terrain map of US overlaid with reflectivity from four, separate radars.

- TDA trend information is being corrupted when in Rapid Update mode. The cause of this problem has not yet been determined.
- Several minor bugs with the output formats were corrected.

Modifications to the TD were drafted and accepted

b) Planned Efforts

1. Continue real-time testing.

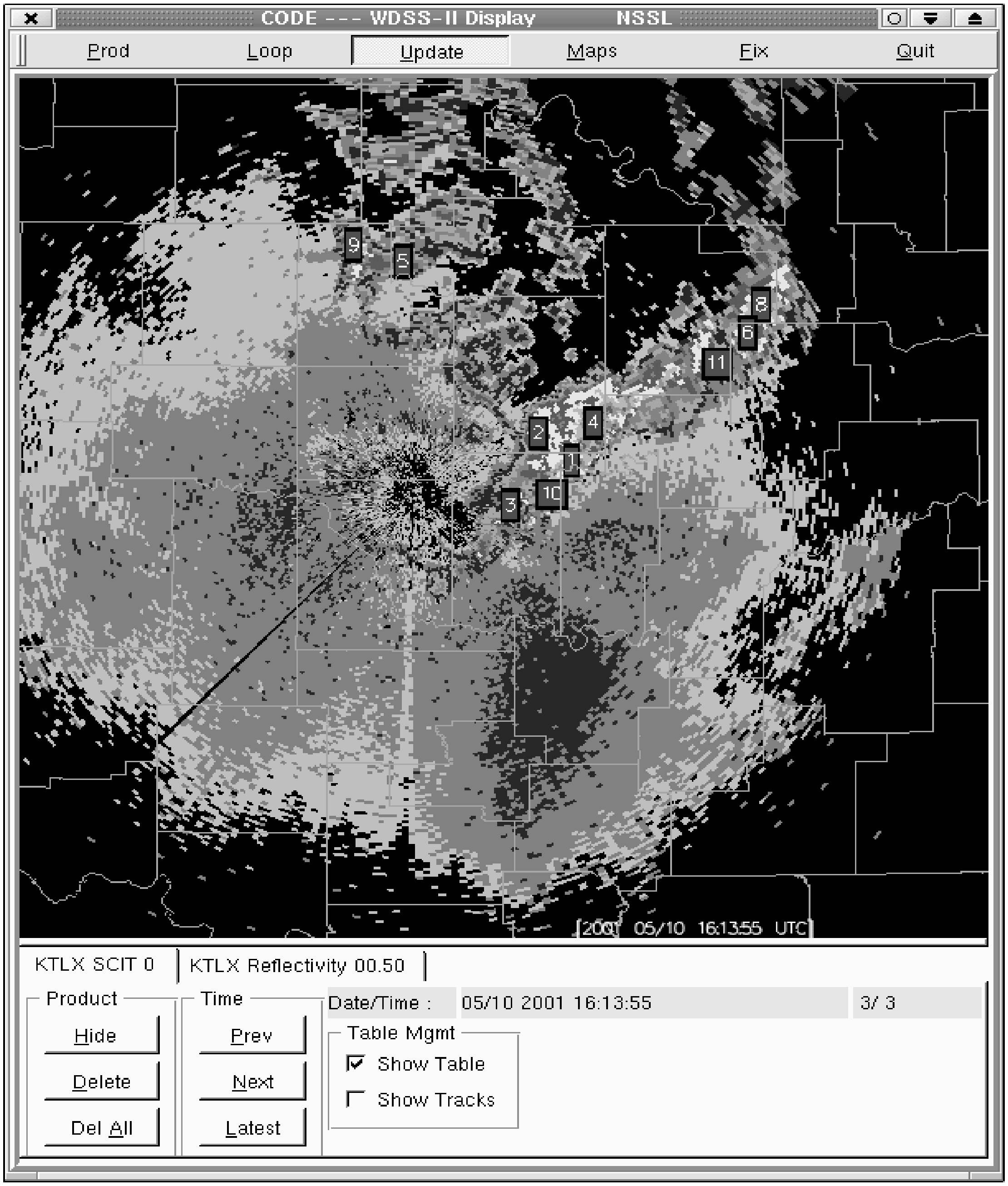


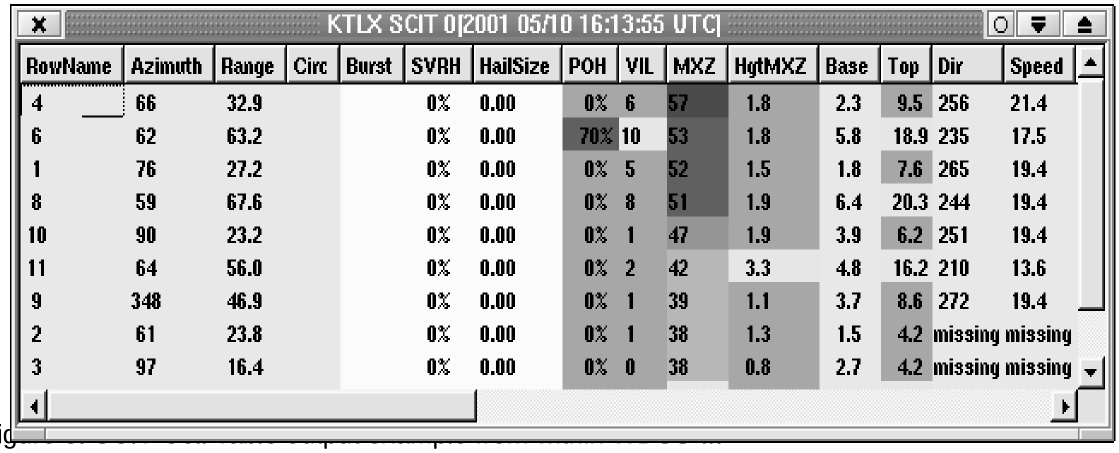
Figure 7. WDSS-II display of reflectivity overlaid with Storm Cell Identification and Tracking (SCIT) algorithm cell ID output.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.



KTLX SCIT 0|2001 05/10 16:13:55 UTC|

RowName	Azimuth	Range	Circ	Burst	SVRH	HailSize	POH	VIL	MXZ	HgtMXZ	Base	Top	Dir	Speed
4	66	32.9			0%	0.00	0%	6	57	1.8	2.3	9.5	256	21.4
6	62	63.2			0%	0.00	70%	10	53	1.8	5.8	18.9	235	17.5
1	76	27.2			0%	0.00	0%	5	52	1.5	1.8	7.6	265	19.4
8	59	67.6			0%	0.00	0%	8	51	1.9	6.4	20.3	244	19.4
10	90	23.2			0%	0.00	0%	1	47	1.9	3.9	6.2	251	19.4
11	64	56.0			0%	0.00	0%	2	42	3.3	4.8	16.2	210	13.6
9	348	46.9			0%	0.00	0%	1	39	1.1	3.7	8.6	272	19.4
2	61	23.8			0%	0.00	0%	1	38	1.3	1.5	4.2	missing	missing
3	97	16.4			0%	0.00	0%	0	38	0.8	2.7	4.2	missing	missing

Fig

01.6.7 Cell and Area Tracking

Integration of the Storm Cell Identification and Tracking (SCIT), the Correlation Tracking (CT) and Scale Separation (SS) algorithms into a single multi-scale precipitation tracking and forecast package.

a) Current Efforts

Software engineering efforts were made to provide the capability of displaying forecasts from MIT/LL's GDST on NSSL's WDSS-II system. Additional efforts were completed to allow the forecasts to be looped in succession. system.

b) Planned Efforts

Future efforts will be focused on getting the GDST to run in real-time within the WDSS-II.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

01.6.9 Composite Products

Develop high resolution radar layer products that are rapidly updated.

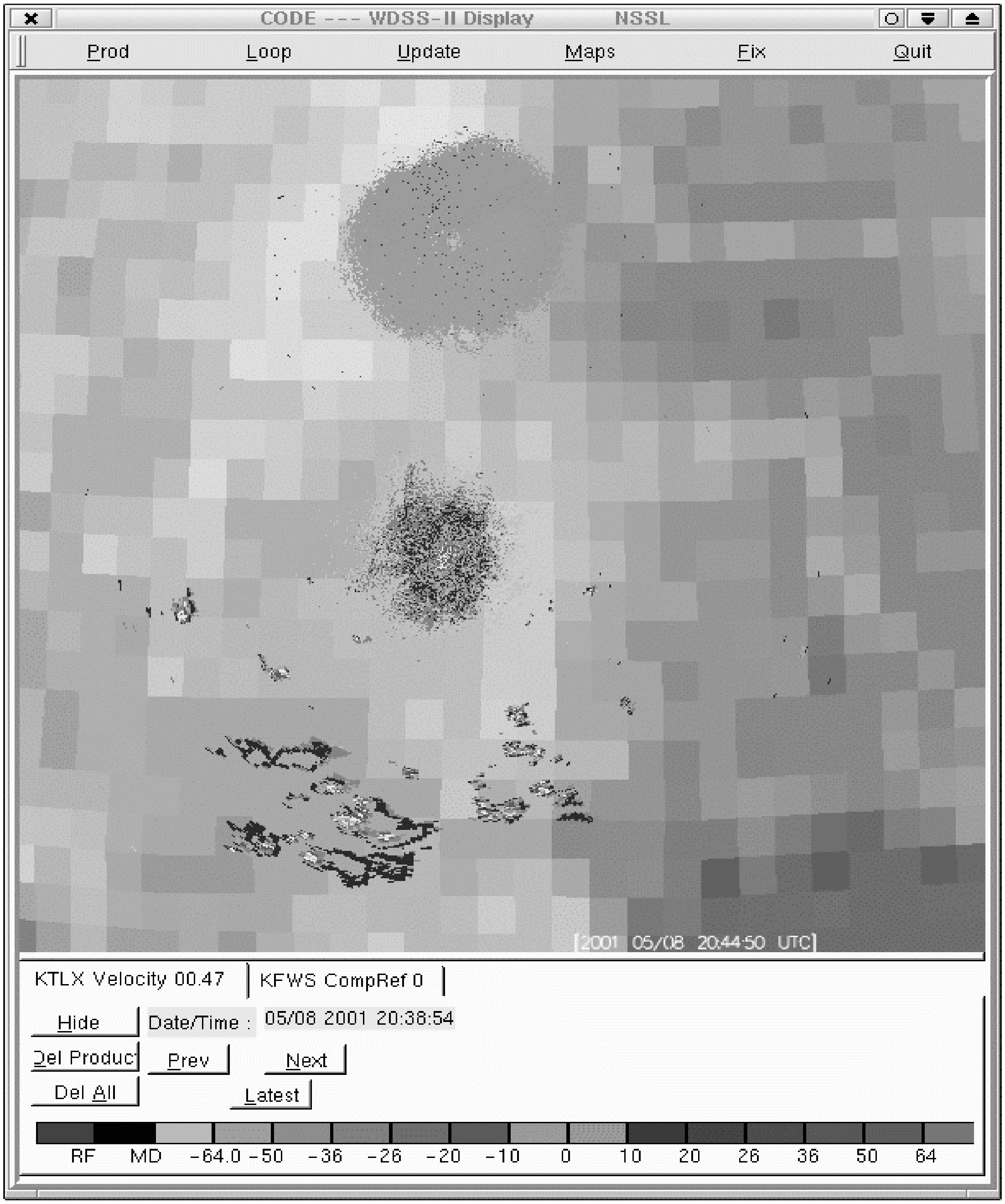


Figure 9. Example of multiple radars displaying different products. The upper-most radar is displaying clear-air velocity, while the lower-most radar is displaying reflectivity.

a) Current Efforts

The activities for this quarter include improvements of the AP (anomalous propagation) and GC (ground clutter) filters by incorporating radial velocity data, satellite IR data and surface (METAR) observations.

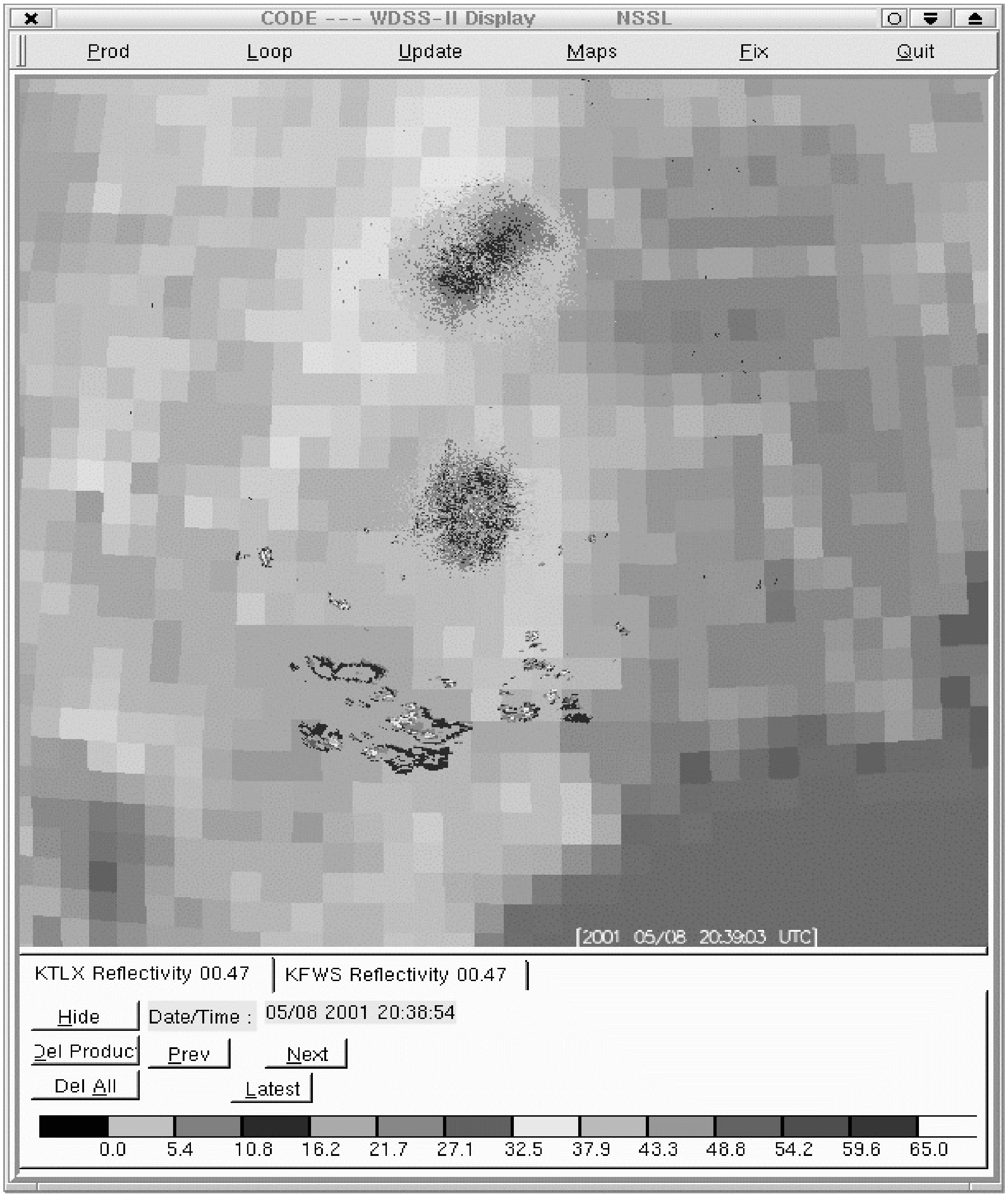


Figure 10. Multiple radars displaying data in real-time on the WDSS-II system.

The radial velocity is used and a zero-velocity rule is combined with the vertical reflectivity continuity rule. This is for removing AP contamination without losing shallow and stationary precipitation echoes. To remove clear air ground clutter and chaff contamination, cloud top temperature fields from satellite IR imagery data are compared with the surface temperature observations. If in any given grid cell the cloud top temperature is within a certain range of the surface temperature, then the grid cell is assumed to be in a clear air region. Documenta-

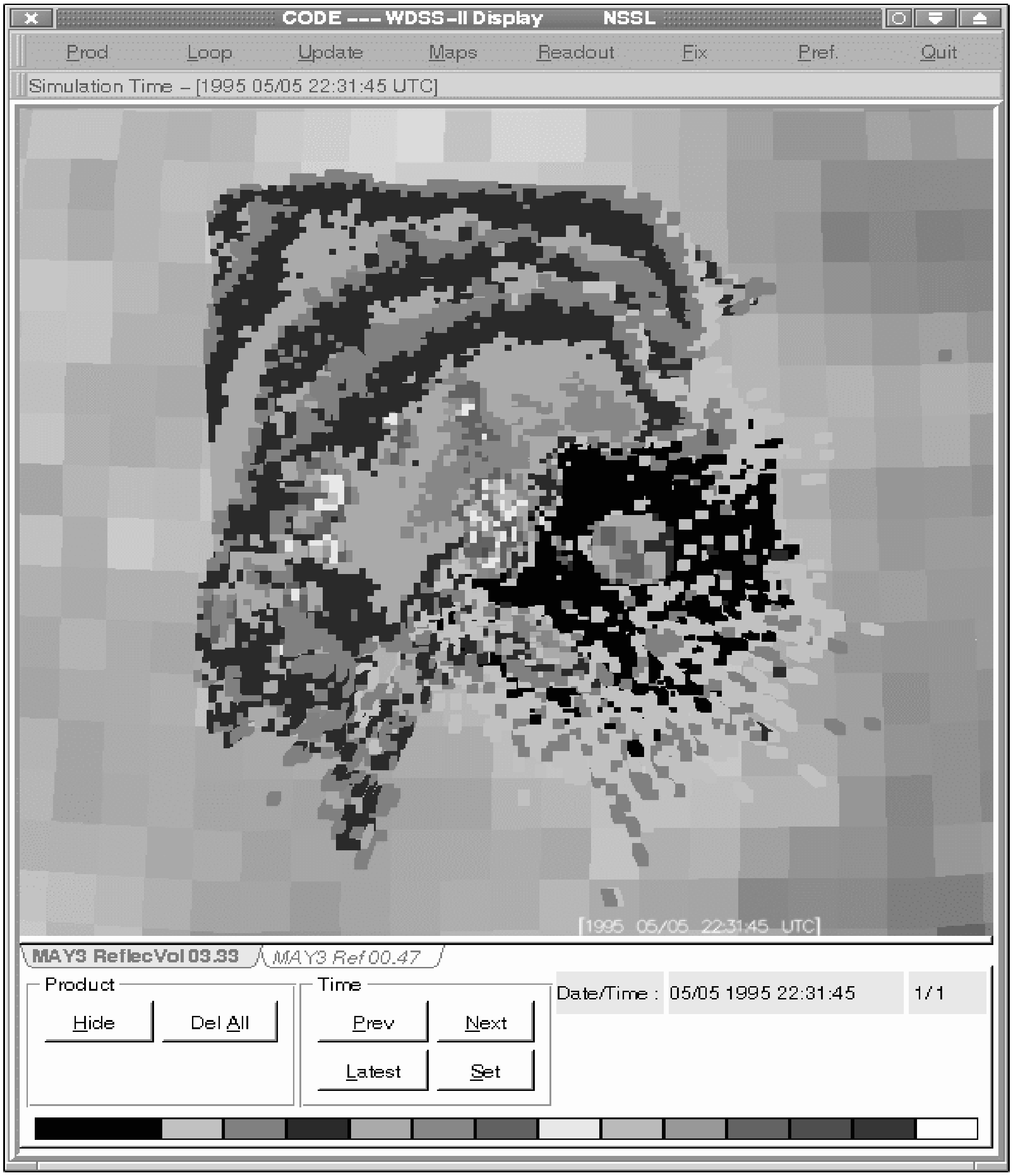


Figure 11. An example of the single-radar, virtual-volume reflectivity product.

tion for the AP/GC removal scheme can be found at http://www.nssl.noaa.gov/wrd/wish/qpe/apremoval/index.htm.

Figures 14a and 14b show examples of a satellite cloud top temperature field and a surface temperature field in the Arizona region. The cool cloud top temperature in the east region of the state indicates cloudy areas and the warm cloud top temperature in the west and south parts of the state indicate clear air region (Figs. 14a and 14b). There are large areas of ground clutter around

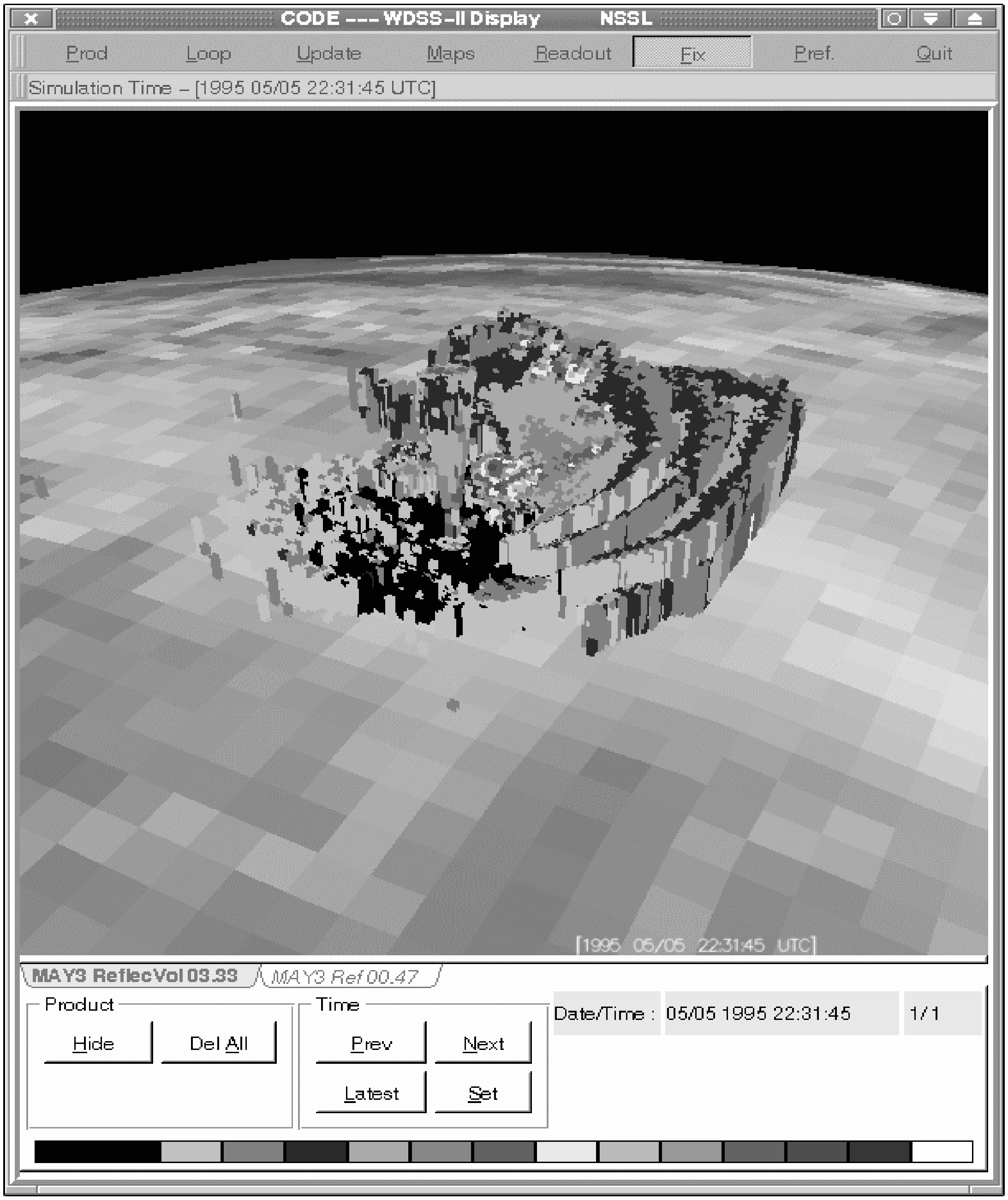


Figure 12. A 3-D view of the single radar, virtual volume reflectivity product.

KIWA and KYUX radar sites (Fig. 15a) and significant chaff echoes near the southern AZ state boundary (mark "A" in Fig. 15a). After the AP/GC removal using the satellite and surface data, the majority of ground clutter and chaff echoes are efficiently removed (Fig. 15b).

b) Planned Efforts

Continue to work with the Mitre on prototype uses of the latest 3D mosaic data and brightband products in en route ATC environment.

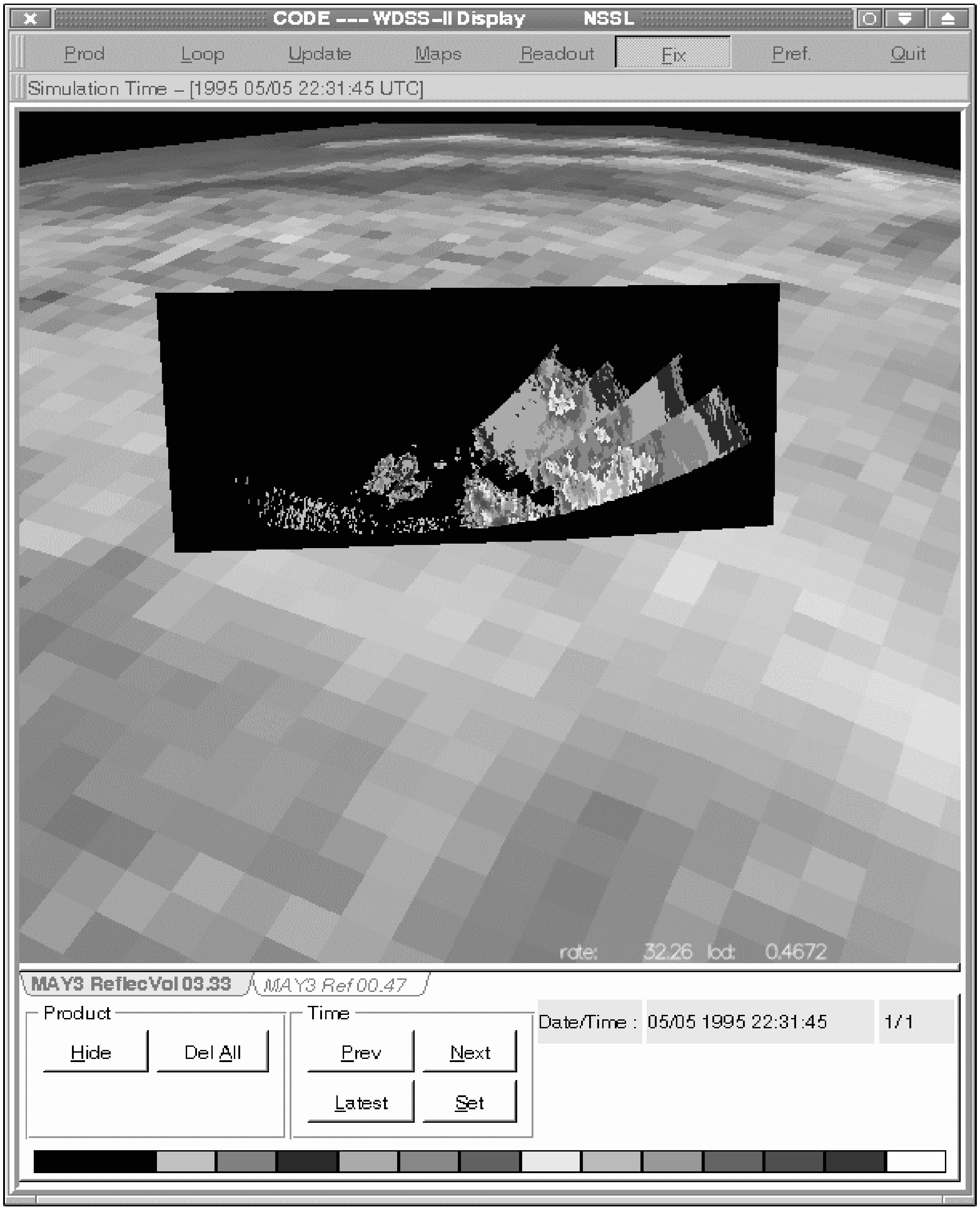


Figure 13. A single radar, virtual volume vertical cross section.

c) Problems/Issues

None.

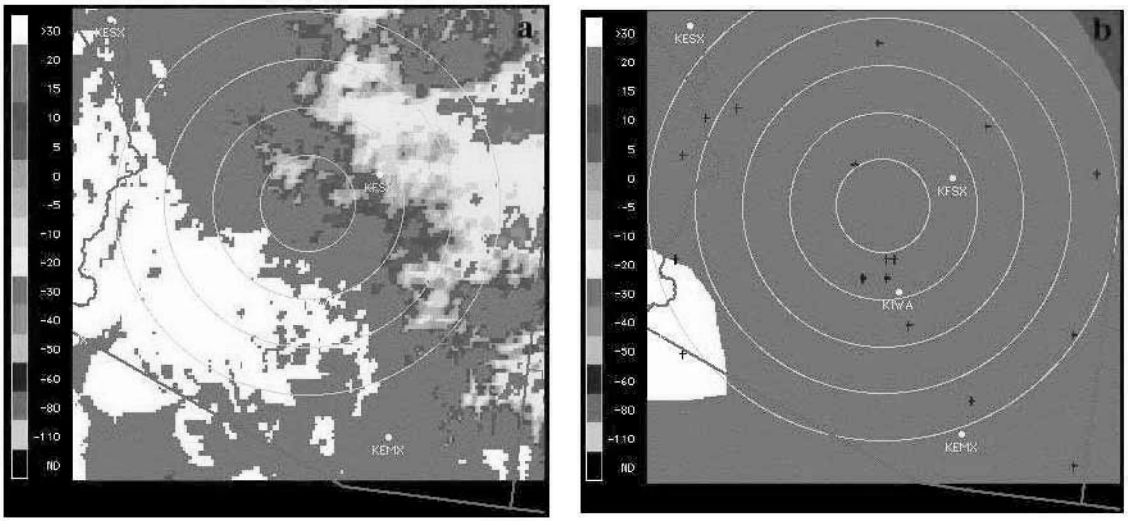


Figure 14. Satellite cloud top temperature (deg C) valid 2045 UTC, 28 March 2001 (a) and METAR surface temperature (deg C) valid 2000 UTC 28 March 2001 (b).

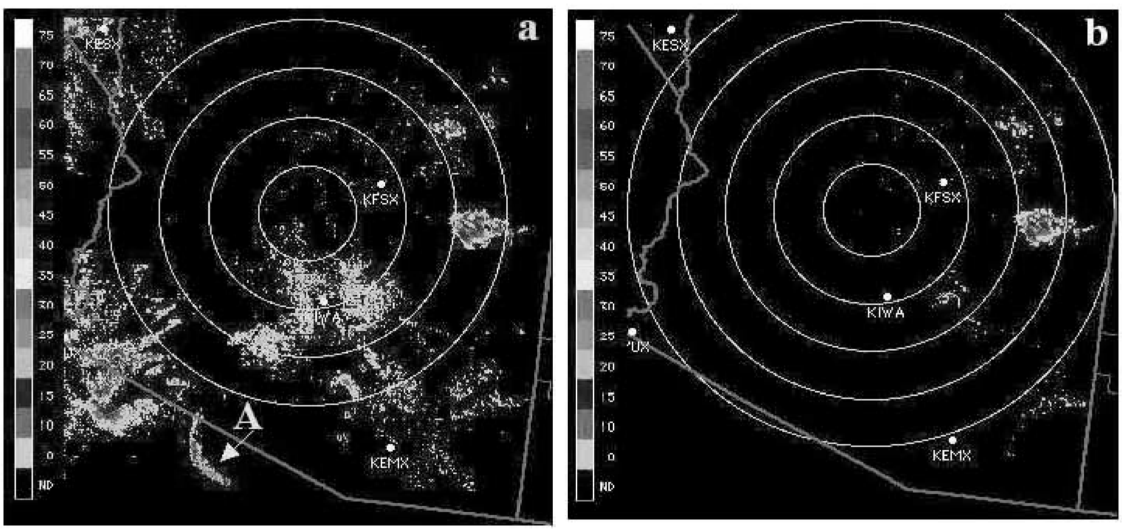


Figure 15. Hybrid reflectivity mosaic (dBZ) before (a) and after (b) the satellite AP/GC removal, valid 2040 UTC, 28 March 2001.

d) Interface with other Organizations

Provided the Mitre with the latest 3D reflectivity mosaic products and bright-band products for prototype display in en route ATC environment.

e) Activity Schedule Changes

None.

01.6.11 Volume Coverage Patterns

Develop and implement Volume Coverage Patterns (VCP's) relevant to the goals of the AWR PDT's.

a) Current Efforts

Collected data on several days using the NSSL's KOUN radar in combination with the RPG at the ROC. Data collection efforts hindered during this quarter due to unavailability of the radar and delays in installing new VCP's on the RPG.

04/16/01	VCP's 56, 57
06/29/01	VCP's 61, 46
06/30/01	VCP's 45, 61, 11, and 21

b) Planned Efforts

Continue analysis and data collection on new VCP's. In particular, check that current algorithms are compatible with new VCP's, and correct any incompatibilities.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None

01.6.12 Product Implementation

Explore and define implementation paths within the aviation community systems that are best for NEXRAD PDT products.

a) Current Efforts

NSSL has installed RIDDS connections to six radars in support of CIWS. A polarimetric algorithm that discriminates between biological scatterers (birds) and non-biological scatterers has been developed. Along with other products, this product was showcased at the PMR in May.

b) Planned Efforts

Continue evaluating the efficacy and appropriateness of NEPDT products.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None

01.6.14 Multi-radar Composites

Develop a vision for FAA use of high resolution, rapid update, composite products which are produced from the integration of multiple WSR-88Ds.

a) Current Efforts

There is no activity for this quarter of task 01.6.14.

b) Planned Efforts

Future activities will focus on merging radar mosaics with WDSS-II display capability.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.

01.6.15 WARP Activities

Examine adaptable parameters associated with NEXRAD data algorithms in WARP and determine optimal settings according to location and season as appropriate.

a) Current Efforts

A white paper titled "Current State-of-the-Art Anomalous Propagation and Ground Clutter Mitigation Schemes: Implications for next generation schemes within The Weather and Radar Processor (WARP)" is finished and has been delivered to Jim Stobie. A PDF version is attached to this Quarterly Report.

Anomalous Propagation and Ground Clutter removal procedures are examined at Massachusetts Institute of Technology/Lincoln Labs (MIT/LL), the Radar Operations Center (ROC) formerly known as the Operational Support Facility, the National Center for Atmospheric Research (NCAR), the National Severe Storms Laboratory (NSSL), the University of Washington (UW), Goddard Space Flight Center (GSFC), and Princeton University (PU). A list of all parameters used within each technique and parameters typically used in various anomalous propagation conditions is given in Tables 1 and 2 of the paper.

While WARP's current anomalous propagation/ground clutter (AP/GC) removal scheme has yet to be tested, it is likely that it can be improved upon in several different ways. NCAR's Radar Echo Classifier (NCAR-REC) has performed very well relative to other AP/GC algorithms. This scheme will be available through the WSR-88D ORPG within the next five years as it is currently slated for release within ORPG Build 2.

It is currently not known if WARP's current AP/GC scheme will perform poorly in tests. But, if a new method is required prior to the availability of the NCAR-REC technique, there is little that could be done to improve the quality of the current scheme. In order to improve it's quality, the WSR-88D Layered Reflectivity Maximum - Anomalous Propagation Remove product would have to be reformulated or improved upon in some manner. By the time this could be done, the NCAR-REC will become available and be the preferred product.

A simple, and potentially very effective, technique could be formulated using radial velocity, spectrum width, vertical gradient of reflectivity, and texture of reflectivity using data supplied through the real-time WSR-88D narrowband connection to each WARP system. IR cloud-top temperature observations could also prove useful to WARP. Because WARP is already receiving satellite information, this information could be readily available. Tests at NSSL show the use of satellite can be particularly effective at removing residual ground clutter and chaff within cloud-free regions.

Continue coordination for NSSL presence at the Operational Test and Evaluation.

b) Planned Efforts

Attend real-time testing of current WARP algorithms at the Ft. Worth ARTCC when the system becomes available.

c) Problems/Issues

None.

d) Interface with other Organizations

None.

e) Activity Schedule Changes

None.